

INTER-SUBJECTIVE INTENTIONAL ACTIONS.

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The other transforms me into an object and denies me, I transform him into an object and deny him. In fact the other's gaze transforms me into an object, and mine him, only if both us withdraw into the core of our thinking nature, if we both make ourselves into an inhuman gaze, if each of us feels his actions to be not taken up and understood, but observed as if they were an insect's. This is what happens, for instance, when I fall under the gaze of a stranger. But even then, the objectification of each by the other's gaze is felt as unbearable only because it takes the place of possible communication.

Merleau-Ponty (1962) pp.360-1.

INTRODUCTION.

Intentions and intentional actions are a fundamental ingredient of our social interactions. The aim of this paper is to better understand the role of intentional action in the constitution of inter-subjectivity. We will develop our view in three parts. The first part addresses the fundamental distinction between interaction with others and representation of others, that is, between others as subjects and others as objects. We will see how the discussion of philosophical arguments on this issue has important implications for the recently established social neurosciences. The second and the third parts of this paper will be concerned with the role of intentional action as the foundation of the type of inter-subjectivity that considers not only the self but also others as subjects. Part (2) argues that inter-subjective relation primarily involves the sharing of a common world. We will describe a process

according to which the relation of the self with objects offers the basis for the sharing of the world with others. This is made possible through the performance of goal-directed actions represented within a shared framework. Part (3) investigates direct self-others interactions. We argue that these inter-subjective relations are not primarily based on inferences but are rather anchored to concrete coordinated intentional actions.

PART 1: OTHERS-AS-SUBJECT.

THE SOVEREIGN SELF AND PHILOSOPHICAL AUTISM.

In philosophy, others are often considered as a problem. In a Cartesian perspective, the very possibility of other subjects questions the model of the sovereign self: The existence of other consciousnesses contradicts the conception of the *cogito* as the radical foundation (Descartes, 1641). Husserl (1929) restates this foundational problem in a different framework. His phenomenology notably¹ advocates bracketing the existence of the objective world, *others included*. Through the *epoche*, others become the ego's phenomenon. Thus, as for Descartes, in this framework, others are only thinkable within the primordial and prior perspective of the self. This view has been pejoratively described as a "philosophical autism" which considers that "my experience of the other person is something that blossoms only within the garden of my own mind" (Gallagher, 2000).

Importantly, it must be underlined that this position, that gives priority to the self over others, prevents from considering others in their specificity. Indeed, "the other person is another subjectivity that refuses to be captured by the epistemic perspectives available to the self-sufficient ego" (Gallagher, 2000). To consider others as subjects in their own right, it is necessary to account for the reciprocity of the self-others relation: not only the self is a subject in relation to others, but the other as well is a subject related to the self.

SELF-OTHERS RECIPROCITY.

The reciprocity of the self-others relation plays a crucial role in Hegel's philosophy (1807). Without going into any detail of his position, it is interesting to note that Hegel establishes that the self does not pre-exist to its relation with others, no more than the other consciousness pre-exists to this relation. In other terms, consciousness reduced to a self-sufficient identity would only be an abstraction. Nevertheless, Hegel's framework does not allow considering others for themselves. Others are only considered as the means of objectifying one's subjectivity. The focus remains the constitution of the self, rather than a co-constitution of self and others. The self-others relation, as Hegel conceived it, is thus not only reciprocal, but also asymmetrical.

In fact, as just exemplified by Hegel's position, reciprocity is both a central feature of the self-others relation and an important problem to solve. This is even clearer in Sartre's account (1943, p.303). Sartre underlines that "the 'being-seen-by-the-Other' is the truth of 'seeing the Other'". However, in a Sartrean context, this reciprocity becomes a problem, if not impossible. Indeed, Sartre insists on the fact that the other's look freezes the self as an object in the world. I recognize that I am as the other sees me. The other's perspective thus immobilizes all my possibilities. I get trapped in the image that the other has of me. Again, this position denies the specificity of inter-subjective relations, since the self loses its subjectivity, as she/he is objectified by the other's perspective.

THE OBJECTIFICATION OF THE SELF AND OTHERS.

An important point to note is that the conception of the self-others relation classically implies an objectification of the self and/or the other: Either others are alienated to the self's perspective, being only a means for its own constitution, or the self is alienated to the others' perspective. Such an objectification makes any genuine encounter of the self and others

impossible: Either the other is considered as subject, a free consciousness, and thus the self is its reified object, or the self takes the other as its object, and the other-as-subject vanishes.

The objectification of the self and/or others takes at least two different forms. As stated by Gallagher: "From either perspective [first- and third-person perspectives], the other appears as an object. From a strict first-person perspective, it appears as an object constituted within the transcendental realm of ownness (e.g., Husserl). From a third-person perspective, it appears as an object that we theorize to be different from all other objects insofar as we hypothesize for it a mental interior (a position psychologists refer to as 'theory of mind²')" (Gallagher, 2000). The other is both the self's intentional object, providing the content of the self's consciousness, and a particular object of the world, i.e. a physical body. As well, the self considers that it can be taken as the other's intentional object of consciousness as far as it is also a physical object of the world. By this double process of objectification, the self can consider itself as an objectified subject and the other as a subjectified object. However, in such a description, self-others relationships are reduced to subject-object relationships. In this framework, when I-as-subject recognize that the other entertains some mental states, I recognize that the particular object that the other is, is also a subject. However, this does not make me interact directly with him as subject (see also Gallagher, 2001). I only attribute some qualities to a particular object that passively receives these qualities. As well, when I consider that the other is taking me as his intentional object of consciousness, this is a relation between $subject_{other}$ and $object_{me}$. Again, this is not a subject-subject relationship, since I am only the receiver of the other's attribution of some quality. Here, we would like to highlight that such a position, that is often taken in the learned literature, misses a crucial point: the subject-subject relationship that is typical of the genuinely reciprocal and dynamical self-others *inter-subjective* relations that we live in our everyday experience.

SUBJECT-SUBJECT INTER-RELATIONS.

Inter-subjectivity literally means "between subjects". Thus, genuine inter-subjectivity implies that both the self and others are subjects, and are subjects for each other. Far too trivial. But, as we just saw, the meaning of this fact is also far too neglected in the literature: Self-other relations are in fact most often described as the objectification of others and of the self through their relation. On the contrary, the $\text{subject}_{\text{me}}\text{-subject}_{\text{other}}$ relation, by definition, implies to consider that, at a given time, both me and the other are subjects in a full sense (Butcher, 2003). An important peculiarity of inter-subjective relation, compared to subject-object relation, is that both the self and the other are more than only receivers of some qualification: Both me and the other are active in an inter-subjective relation. Not only the self is active in what he receives and gives, but crucially both selves are. Thereby, the self (or the other) alone cannot constrain the whole inter-relation.

Importantly, this implies that what the self is, the mental states he entertains, and the behavior he shows, is not fully determined by herself or himself taken in isolation. Rather, it also depends on the other and on the self-other relation. What the self is cannot be established statically, prior to its relation with others, if inter-*subjective* relations can be possible at all, since such an *a priori* fixation would allow only a subject-object relation. In other words, inter-subjective relation engages the two interacting subjects in a process of auto- and inter-constitution. Others participates to the organization of the self (the organization of his mental and behavioral states), and reciprocally, the self participates to the organization of the other.

We will not develop this view on the self constitution here. Rather, in the next two parts of this paper we will discuss the subject-subject give-and-take processes, in a naturalistic perspective.

FROM PHILOSOPHY TO SOCIAL NEUROSCIENCES.

At this point, a non-philosopher cognitive scientist may wonder what the concrete implication of such a view is for her/his own perspective. Are all these considerations only coming from the heads of philosophers and interesting only within a philosophical framework? On the contrary, the field of cognitive neuroscience has recently merged with social neuroscience into the exciting field of social cognitive neuroscience, and the distinction between others-as-object and others-as-subject is crucial in this perspective. This distinction has to be taken into account in the design of experimental protocols and in the interpretation of the results. Indeed, numerous data apparently contradict each other, partly because what is measured is not sufficiently specified. Most notably, we propose to distinguish three levels of self-others relation, whether it involves (1) non-interactional observation of others, (2) interactional observation of others or (3) on-line interaction with others. Only the latter involves a genuine subject-subject relation, and allows to investigate the role of intentional action in the constitution of inter-subjective relation between self and others. The rest of this paper will focus on this point. But before doing so, let us discuss briefly how the three levels of self-others relation have been implemented in social cognitive neuroscience.

OBSERVATION AND ATTRIBUTION.

The first case (1) implies a $\text{subject}_{\text{me}}\text{-object}_{\text{other}}$ relation. It is in place in any experiment where the subject has to make some judgment about the other. It is the equivalent of the experiments where the subject has to make some judgment about himself, taking himself as his own object. In fact, these two types of experiment are often combined together. For example, the subject can be given the following instruction: "If the face on the screen looks more like you, press the right button with your right index finger, if the face looks more like the other person, press the left button with the left index finger" (Kircher et al. 2001).

Importantly for the point at stake here, and as noted by Uddin et al. (in press), in this experiment, a blocked design is used, which does not emphasize the discrimination component of the task since each block contains mostly stimuli from one category. No part of the task requires direct comparison between a self and another's face. Uddin et al. own experiment is very similar to Kircher et al. one. The task of the subjects is the same but in this study, this task is performed in an "interactional" (even if restricted) context. Indeed, the event-related design forces subjects to make "self-other" discrimination for each trial. Thus, the result of Uddin's study may be more related to self-other discrimination than to perceptual processing of the images, as in Kircher et al.. Kircher's study is thus better described as a case of non-interactional observation (1), while Uddin's study would rather correspond to a case of interactional observation (2).

The distinction between these two protocols may appear insignificant, but it is in fact related to different brain activations. In Kircher et al., the processing of self's face images, compared with the processing of other's face images, reveals greater responses in left fusiform gyrus, left inferior frontal gyrus, left supramarginal gyrus/inferior parietal lobule, and right middle temporal gyrus, right insula, and right hippocampal formation. In Uddin et al., the self-other discrimination task modulates activity in a network involving frontoparietal structures described as part of the human "mirror neuron system" in the right hemisphere, and in two areas of the so-called "default/resting state". These two large-scale neural systems have been identified as crucial systems for the processing of social relations (Iacoboni et al, 2004), thus supporting our interpretation on the interactional nature of Uddin's task.

The distinction between non-interactional observation of others and interactional observation of others is clearly implemented by the contrast between two experimental conditions: observation of other's actions to imitate them and observation of other's actions to later recognize them. Only the former corresponds to what we call here interactional

observation of others. It is correlated with activation in the SMA, the middle frontal gyrus, the premotor cortex, and the superior and inferior parietal cortices in both hemispheres, while observation of action for recognition purposes activates mainly the parahippocampal gyrus in the temporal lobe (Decety et al., 1997; Grezes et al., 1998, 1999). These data strongly suggest that a context of imitation³, implying interaction between self and others, involves neural systems quite different from the ones used for recognition processes not to be used in on-line interactions.

ON-LINE INTERACTION.

We just differentiate non-interactive and interactive observations of others. We can now differentiate both of them from (3) on-line interaction. Contrary to the two former ones, the latter does not involve judgment and attribution, but coordinated actions. Obviously, to interact with others also implies to "observe" others. But this is not what we call here an observational attitude, because the observation is specifically made in an interactive context, and does not reduce the other to an object of observation and attribution. As stated by Gallese (2005): "when we are involved on-line with social transactions, we experience a totally different attitude toward the objects of our perceptions. There is actually a shift of the object of our intentional relation. We are no longer directed to the content of a perception in order to categorize it. We are just *attuned to the intentional relation displayed by someone else*....By means of *intentional attunement*, "the other" is much more than a different representational system; it becomes a *person*, like us".

What is relevant to differentiate observational and interactive relation with others is the context in which the other is encountered. Most importantly, different data suggest that *in ecological situations*, the mere looking at other subjects and/or agents involves what we call here an on-line interaction. First, it is now well-known that observing another's action and

executing oneself the same action involve partly common neuronal activations: this is the so-called mirror neuron system (Gallese et al. 1996; Rizzolatti & Craighero, 2004). In the present context, this suggests that when the task is merely to watch other agents, an interactional link between oneself and the other is activated. As stated above, this same link may not be activated in a more constrained task, for example when the subject has to attribute some mental and/or physical properties to the other, thus considering him as an object of observation, judgement and attribution.

The claim that simply facing others in ecological situations already involves an interaction is also supported by data recorded during an experiment where the subject just had to look at movies showing people interacting (Iacoboni et al., 2004). Interestingly, brain regions that are typically activated in non ecological laboratory situations are not activated by the presentation of the naturalistic social stimuli used in this experiment. The dorsolateral prefrontal cortex, often associated with reasoning, monitoring and control; the anterior cingulate cortex, also associated with monitoring and control; and the lateral aspect of the posterior parietal cortex, often engaged in attentional tasks are not activated by the observation of the movie clips. Overall, the pattern of results obtained in this context, suggests that the processing of social stimuli (apart from experimental artificial manipulations) is a continuous process importantly involving on-line (non-attributional) interactions between $\text{subject}_{\text{me}}$ and $\text{subject}_{\text{others}}$, rather than a controlled inference. Moreover, it suggests that such inter-subjective interactions involve very primary processes, thus providing a strong basis for further development of the other forms of self-others relations.

The claim we want to make here is not to privilege one or the other of the three types of relation between self and others we described. Rather, our point is only to clarify these relations and their specificities, rather than ironing them out under what would be called a "neuronal signature of other consciousness"⁴. The differences between non-interactional

observation, interactional observation and on-line interaction are not only nominal, as they are reflected at the level of brain activations, as we just saw. To further support our position, we will now detail which roles intentional actions and interactions play in on-line inter-*subjective* self-other interactions. Specifically, the next part will bring some content to the claim that the give-and-take processes playing a role in the constitution of inter-subjective relations is primarily based on the sharing of a common world between two subjects, through the mediation of their respective goal-directed actions. Part (3) will investigate direct inter-subjective relationships and provide some data from cognitive neuroscience suggesting that they are not restricted to inferential attribution of mental states to others (as classical theories of mind suggest), but crucially involves the coordination of self's and others' intentional actions.

PART 2: SHARING A COMMON WORLD.

BEING IN A WORLD OF OTHERS.

Our previous discussion has allowed us to support the idea that genuine inter-subjective relation primarily involves two subjects interacting on-line. This part intends to show that such a conception of inter-subjectivity allows to understand a basic form of self-others relation: the sharing by the self and the other of a common world where to act.

The idea that some inter-subjectivity can be found in the subject's relation to the world has been defended in different forms in phenomenology. As recalled by Zahavi (2001) "In *Being and Nothingness*, Sartre nicely sums up Husserl's position in the following manner: 'Thus, each object, far from being constituted as for Kant, by a simple relation to the *subject*, appears in my concrete experience as polyvalent; it is given originally as possessing systems of reference to an indefinite plurality of consciousnesses; it is on the table, on the wall that the Other is revealed to me as that to which the object under consideration is perpetually

referred—as well as on the occasion of the concrete appearances of Pierre or Paul’(Sartre, 1943, p. 278)”. In other words, for these authors, objects of the world are experienced as public. They cannot be reduced as the self's own intentional objects. Rather, they are also experienced by others. This implies that, prior to the concrete perceptual encounter with another subject, inter-subjectivity already exists in the perception of the world. This co-reference to a common world bases Husserl's notion of *transcendental inter-subjectivity*, which means that inter-subjectivity allows the constitution of the world as objective. Indeed, when the self becomes able to consider that objects are experienced by others, his relation to objects is modified: being accessible to others, objects can be experienced as objective.

Although we agree that "Under normal circumstances we understand each other well enough through our shared engagement in the common world" (Zahavi, 2001, p.155), we also think that this position suffers from an important problem: defining inter-subjectivity *beyond* the concrete encounter with other subjects, this view may neglect the specificity of real on-line interactions. Here, we would like to argue that a "middle course" may be considered, which suggests that inter-subjectivity can be based on a real encounter with others mediated by their relations to objects. We will now develop this position.

To better understand the link between oneself, the world and others, let us first give an example. A predator is pursuing a prey. At one point, the environment presents a hole, providing a potential hiding-place for the prey. The attentive predator, as well as the prey in despair, perceive the hole, and act accordingly. The predator changes his trajectory in order to intercept the prey before it enters the hole and the prey is thus obliged to modify its trajectory according to the predator's trajectory. Consider now the next day. The now starving predator is hunting a bigger prey. They cross the same place as the day before, the prey orienting by chance its course toward the hole. This time, however, the hole is too small to hide the prey. The predator thus continues with a direct trajectory towards the prey, not taking into account

the hole as a possible hiding-place. Thus, what the predator perceives and how he organizes his behavior has changed, according to the relevance of the environment *for the prey*. It means that the way one perceives and acts in the world is modified according to how others perceive and act themselves in the same shared world.

This example provides us with the idea that one's being-in-the-world depends on others and on their own relation to the world. What a subject perceives is made relative to what others can perceive or not: the world is shared. Being-in-the-world is notably for the self to be in a world of others. Here, we thus find the idea that inter-subjectivity can be mediated by the self's and other's relations to a common world.

TRIANGULAR RELATION.

The crucial point of our proposition is that a form of inter-subjectivity would be based on a triangular relation between the subject, the object and the other. Indeed, three links are essential: first, the subject is linked to the object, as it perceives it and acts on it; second, the other subject is linked to the object as well; thirdly, the subject is linked to the other in that it recognizes that it is linked to the object (Fig. 1). The link between the subject and the other is made through the mediation of the object, by virtue of the fact that the object is reachable not only by the subject itself but also by another subject. Through the inclusion of the other's perspective, the object now exists beyond the context of the self's own restricted access to it. The world is "understood" as reachable by others, and, in that, as exceeding the self's own perspective. This new perspective changes fundamentally one's representation of the world: the world is not for myself exclusively, but for "us". In this sense, the self's relation to the world is basically inter-subjective. Importantly, this inter-subjectivity of one's being-in-the-world as a being-in-a-common-world is not produced by a direct link between the self and the

other. Rather, self and others are here related through their relation to the world, by the sharing of it. This is what we mean by "triangular relation"⁵.

SHARING BY ACTING.

We hold here that a primary form of inter-subjectivity takes the form of a sharing of a common world, thanks to the simultaneous existence of both one's and the other's perspective on objects. To clarify the notion of triangular relation we are specifically investigating here, we will consider the most basic way to have a perspective on the world. To have a perspective is to have an access to the world, access that is particular, limited in that it does not give the whole reality. Our proposition is that the most primary, concrete and observable way to consider others' perspectives on the world is to consider others' motor accesses to the world, that is, to observe others acting. This approach is the most parsimonious and most relevant to a naturalizing approach, in particular as compared to the ability to imagine that an action could take place, or that a perspective could be held (Grush, 2001).

The subject accesses the world through its action not only by reaching and grasping objects physically, but also by constituting motor representations of objects (Berthoz, 1997; Gibson, 1982; Paillard, 1971, 1991; Varela, Thompson & Rosch, 1991). This position is supported by some electrophysiological recordings, specifically, the recordings of a category of visuo-motor neurons in the area F5 of the cortex of the macaque monkey (Rizzolatti et al. 1988; Murata et al. 1997). These neurons, called "canonical neurons" show two types of activity. They are active during the execution of a goal-directed action, and are also active even though the monkey does not execute any movement, but is just observing an object that is potentially a goal of action. This period of observation does not have to be followed by any execution of action for these neurons to be activated. Such a pattern of neuronal activity suggests that the subject sees the object through "motor eyes", that is, following motor

constraints. The potential interaction of the actor with the object is what gives a meaning to the pictorial description of objects and environment given by the visual system. The activity of canonical neurons illustrates the role of (potential) action for the constitution of the meaning of the world. Indeed, the meaning of the object is not what the subject reads passively from the already written open book of the world. Rather, the subject is the very actor of the content of his perception of the world. We are thus in a position to say that, at least for a part, the subject sees the object in the context of its own (potential) action. This fact provides the basis for our investigation of the sharing of the world with others at the level of action.

To share the world necessitates that the motor representation of the object is not limited to one's own action only. More precisely, the subject must be able to entertain a motor representation of the object that is dependent on her/his own action as well as on actions executed by others. This is a way to detach the object from one's own action only, and thus to share it with others.

The idea that action execution and observation correspond to a triangular relation as described here is strengthened by some neurophysiological evidence, namely, the recording of mirror neurons activity in the area F5 of the cortex (Gallese et al., 1996, Rizzolatti et al., 1996; Fadiga et al., 1995; Rizzolatti et Craighero, 2004). Mirror neurons activity is widely known as involving a representation of action that provides a link between oneself and others (Gallese and Goldman, 1998; Gallese, 2001). Here, we will specify how this link can be understood in relation to one's being-in-the-world and being-in-a-world-of-others.

A first characteristic of mirror neurons, where their name comes from, is the mirroring of the actions of the agent and of the observer. Indeed, mirror neurons are active when the subject executes a goal-directed action, as when she/he merely observes another agent (the experimenter or another monkey) doing the same action. This suggests that a partly common

representation of action is activated both during action execution and action observation. Moreover, mirror neurons activity is most often correlated with the reaching of the goal, rather than with the way the goal is reached: some neurons are active when the action to grasp a piece of food is done with the hand as well as when it is done with the mouth. Mirror neurons are not active during the observation of the object alone (contrary to canonical neurons described above), nor during the observation of the agent alone. Nor are they active in a situation in which the action is mimicked without achieving the goal (Gallese et al., 1996). In this case, the action takes place, but the link between the agent and the object is not completed.

According to this collection of data, mirror neurons activation can be said to correspond to the representation of goal directed actions. This characteristic of mirror neurons clarifies the sense by which these neurons can be said to be "mirror". Indeed, mirror neurons activity links oneself and others through their goal-directed actions, that is, *through their relations to the world*. This is why action execution and action observation correspond to a triangular relation (Fig. 1): mirror neurons are active when an agent acts on an object, and when he observes another agent acting towards an object, that is, both for the link between the agent and the object, and for the link between another agent and the object. Such a property allows to understand that the neurons called "mirror" provide a basis for the sharing of common representations of the world, through actions directed towards goals. In this sense, these neurons could have been named "sharing neurons". Such a sharing of the world implies a basic inter-subjectivity that is acted in concrete self-others encounters mediated through the relation to objects.

ACTED INTER-SUBJECTIVE RELATIONS.

Our approach centered on action makes clear that the process of triangular relation we discuss here, and thus the basic inter-subjectivity based on it, does not imply the ability to attribute mental states to oneself nor to others. Rather, what is involved here is the motor access to the world and not a mental perspective on it. Agents are related to objects by acting on them and they are related to each other by observing these goal-directed actions.

In addition, it must be clear that the process of triangular relation described here does not presuppose the ability to entertain inter-individual linguistic communication. Moreover, our position highlights the role of others in the cognitive development of an organism, without restricting it to the limited context of learning, for example through cooperation or imitation⁶. At a behavioral level, it is evident that the actions of others are taken into account, before the development of language, and outside a context of learning. This is especially true for highly social species like humans and monkeys, but also for non-social species: most animals have to consider others' action in the environment in order to be efficient predators and not easy preys.

To summarize, our proposal is that a primary inter-subjective relation is made possible through the sharing of a common world, by virtue of the execution and observation of goal-directed actions: the goal of one's action becomes represented as something that can be shared in the sense that the object is not only one's own intentional object but also the intentional object of others. Obviously, though, inter-subjective relations are not limited to this basic level of triangular relations. We investigate more sophisticated and direct self-others interactions in the next part.

PART 3: SHARING COORDINATED ACTIONS.

UNTHEORETICAL PRACTICE.

In developmental psychology, the most classical way to investigate the ability to entertain inter-subjective relations uses the so-called false-belief task (Wimmer & Perner, 1983). In this kind of experiment, the subject is asked about what another person would think and do in the described situation. For example, the subject is told or shown (with drawings) that a person moves a piece of chocolate from a box to a cupboard. Later, a second person that did not see the piece of chocolate being moved, enters the room. The subject has to tell whether the second person will search the chocolate in the box or in the cupboard. Four-year-olds generally answer correctly that the second person thinks that the chocolate is in the box, whereas three-years-olds are unable to consider that the other person has different knowledge, and thought, from themselves. They thus answer that the second person thinks that the chocolate is in the cupboard.

Gallagher (2001) has raised questions about certain background assumptions that shape the design of such experiments and the interpretation of their results. He points out that in these experiments the task is to predict the mental states and behavior of others with whom the subject is *not* interacting. But, as stated above, a third-person observation does not adequately capture the way we interact with others directly in second-person relationship. Moreover, theories of mind imply that our understanding of others is based on theories or internal simulation. As pointed out by Reddy & Morris (2004), this view hides a mind-behavior dualism, whereas "we do not interpret our action on either an abstract physiological level (I am activating a certain group of muscle) or in terms of a mentalistic performance (I believe P so I will do X)...Rather quite naturally we understand our own actions on the highest pragmatic level possible" (Gallagher, 2001, p88). The same goes for others: "we interpret their actions in terms of their goals and intentions set in contextualized situations, rather that abstractly in terms of their muscle performance or their beliefs" (p88). It is "body

reading, rather than mind-reading" (p90). Far from being mediated by theories of mind, inter-subjective relations rather rely on "practice of mind" (Gallagher, 2001).

This position joins the Heideggerian existential phenomenology (1927) in that it conceives our way of being in the world as primarily pragmatic (based on action and interaction according to environmental and contextual factors), rather than mentalistic or conceptual (based on prediction and attribution, mediated by mental contents): "the less we just stare at the hammer-Thing, and the more we seize hold of it and use it, the more primordial does our relationship to it become, and the more unveiledly it is encountered as that which it is" (1927, p.98). The current position holds the same perspective on self-others inter-subjective relations.

INTER-SUBJECTIVE ACTIONS: THE CASE OF IMITATION.

Neuroscientific experiments investigating specifically on-line self-others interactions are very hard to design, since it requires that people interact on-line in a scanner, which is practically very difficult at this stage (see also Gallagher, 2001, note 18). In this framework, imitation provides a much interesting protocol for the investigation of this level of on-line interaction between self and others.

Imitation provides a good example of embodied inter-subjective practice. It also makes particularly clear the idea that humans unfold their activities according to a coordinated framework of actions, gestures, and beliefs, expectations that go beyond the individual expression of intentional relations. Imitation is a key factor in the emerging ways of achieving social coordination among toddlers.

What are the neural and cognitive aspects of imitation? A variety of systems and cognitive neuroscience approaches, from fMRI and PET to TMS and neurophysiological recordings, suggest a 'minimal neural architecture' for imitation. This 'minimal neural

architecture' provides critical computations for imitative behavior and is composed of superior temporal, posterior parietal, and inferior frontal cortex (Iacoboni, 2005). The information flow within this large-scale network would go as follows:

- the superior temporal cortex provides a visual description of the observed action to be imitated to posterior parietal neurons matching observation and execution of action (*mirror* neurons).
- the posterior parietal *mirror* neurons provide additional somatosensory information regarding the action to be imitated (Iacoboni et al., 1999) and this information is sent to inferior frontal *mirror* neurons.
- inferior frontal *mirror* neurons code the goal of the action to be imitated (Iacoboni et al., 1999; Koski et al, 2002).
- efferent copies of motor commands providing the predicted sensory consequences of the planned imitative actions are sent back to STS (Iacoboni et al., 2001).
- in STS occurs a matching process between the visual description of the action and the predicted sensory consequences of the planned imitative actions; if there is a good match, the imitative action is initiated; if there is a large error signal, the imitative motor plan is corrected until convergence is reached between the superior temporal description of the action and the description of the sensory consequences of the planned action.

This neural architecture maps onto a computational architecture for motor control composed by internal models (Iacoboni et al, in press). Internal models are neural mechanisms that can mimic the input-output characteristics of the system. Inverse models are important for motor control, whereas forward models are important for motor learning. An inverse model retrieves the motor plan necessary to reach a desired sensory state. The input of the inverse model is the desired sensory state and the output of the inverse model is the motor

plan necessary to reach that desired sensory state. In our case, the imitator desires to imitate the action of the actor, and an inverse model is created by STS inputting the visual description of the observed action into fronto-parietal mirror areas that produce the output of the inverse model, the motor command necessary to imitate the actor. An efferent copy of the motor command (from fronto-parietal mirror areas) is fed into STS to create a forward model that allows predicting the sensory consequences of the planned imitative action. A forward model is a mimic of the motor system and if the prediction is confirmed by re-afferent feedback, then the forward/inverse model pair is reinforced by a 'responsibility signal' that assign high responsibility for imitating that given action to that specific forward-inverse model pair.

Coordinated social activity and complex intentional interactions emerge from this sub-personal architecture for motor control and imitation. The key factor is the thick fabric of our shared social practices. We have observed and performed ourselves the actions that form our shared social practices and our everyday coping skills over and over again. They provide the background against which meaning in social interactions emerge.

The main claim here is that we are at first, originally, initially, in a primal way, agents embedded in interactions. The interactions are made out of a fabric of sub-personal acts, gestures and goals, forward and inverse models. From this fabric, a coordination process emerges at supra-personal level, forming the social relation between interacting humans. In all this, the third-personal, non-interactive observation of others is often times interfering, clumsily, in the flow of give and take that makes an interaction possible.

CONCLUSION.

The view defended here does not restrict social understanding to inferential mechanisms borrowed from 'non social' cognition. Rather, social understanding is embedded in 'non theoretical' cognition, and it does not correspond only to the attribution of mental

states to others. Specifically, social understanding is anchored to intentional action, as it implies, in the first place, the understanding of others' action as intentional. That is, the others are not only endowed with mental states, but are also agents executing intentional actions towards goals. At this level, self-other relations are interactional, in the sense that they involves two (or more) subjects interacting with each other and with the world, through the coordination of their intentional actions.

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NOTES

¹ Note that Husserl has developed different considerations of others, at different levels. He notably introduced the concept of "transcendental intersubjectivity" (Zahavi, 2001). We consider this view more in detail in part 2.

² Cf. part 3.

³ More data on imitation are presented in part 3.

⁴ The same is true as well for self-consciousness (Legrand, 2003).

⁵ A similar notion of "triangulation" is also central in Davidson's theory (1991). By this idea, Davidson argues that knowledge of oneself, knowledge of others and knowledge of a

common objective world form an interdependent set of concepts no one of which is possible in the absence of the other ones. We will not detail his theory here, since his aim is principally to understand linguistic behavior, and thus differs from ours. What remains common is the focus on the relationships between a subject (a speaker, for Davidson; an agent, in our position) and both its social and physical environments.

⁶ Cf. Part 3.